Saskatchewan
Environment

Hydrology Branch

1982 Operation of the Saskatchewan River System

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1982 OPERATION OF THE SASKATCHEWAN RIVER SYSTEM

HYD-6-50

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Chapter I

INTRODUCTION

A. GENERAL

This report describes the flows and operations that occurred on the Saskatchewan River system in Saskatchewan for the calendar year 1982. The operations at Lake Diefenbaker and Tobin Lake are the main focus of the report. A key map of the river system is shown on Figure 1.

B. CONDITIONS AT THE END OF THE 1981 CALENDAR YEAR

Flows in the fall of 1981 on the South Saskatchewan River were below normal and on the North Saskatchewan River were above normal. South Saskatchewan River flows were above normal in the spring and summer of 1981. Lake Diefenbaker reached a maximum elevation of 556.83 metres (m) while Tobin Lake approached its maximum storage capacity. By December 31, 1981, water use during early winter had drawn Lake Diefenbaker to an elevation of 552.78 m, compared to the fsl of 556.87 m and Tobin Lake to an elevation of 313.10 m compared to the fsl of 313.64 m.

Flows in the South Saskatchewan River above Lake Diefenbaker in December, 1981, averaged 53 cubic metres per second (m^3/s) and the North Saskatchewan River at Prince Albert averaged 149 m^3/s. The normal December flows are 110 m^3/s and 115 m^3/s respectively for these locations.

C. REPORT OUTLINE

This report outlines the flows and operations for the 1982 calendar year at Lake Diefenbaker and Tobin Lake. The first chapter provides a general introduction. The second chapter describes the flows that occurred and the water supply forecasts that were developed for operation planning at various times throughout the year. The remaining chapters of the main text discuss the operation of the generating stations, the consumptive withdrawals, the Qu'Appelle River Dam releases and special operation problems encountered in 1982. A detailed documentation of the historical development on the Saskatchewan River system in Saskatchewan and operation criteria can be found in Appendix A.

Figures 1 to 6 show some key maps of the Saskatchewan River system, the Gardiner and Squaw Rapids dams and the storage characteristics of the lakes behind both dams.

Chapter II

INFLOW SUMMARY AND WATER SUPPLY FORECASTS

A. GENERAL

The year 1982 was a normal runoff year on the Saskatchewan River system, with the North Saskatchewan River at Prince Albert at approximately 110 per cent of normal and the South Saskatchewan River Lake Diefenbaker inflow at approximately 85 per cent of normal. In each case the flows reflect the seasonal precipitation which is illustrated on Figures 7 and 8.[1]/ Figure 9 shows the South Saskatchewan River inflows and outflows for Lake Diefenbaker and reservoir elevations. Figure 10 shows the North Saskatchewan River flows at Prince Albert.

The average flow of the South Saskatchewan River into Lake Diefenbaker for 1982 was 192 m^3/s compared to the normal of 220 m^3/s.

The average flow of the North Saskatchewan River at Prince Albert for 1982 was 249 m^3/s compared to the normal of 225 m^3/s.

The average monthly flows of the North and South Saskatchewan Rivers for 1982 are listed in Table 1.

1/ Precipitation during November and December, 1981 was mostly snow that did not melt until 1982. Similarly, precipitation in November and December of 1982 is not included in this report because it contributed to the 1983 runoff.

Table 1

NORTH AND SOUTH SASKATCHEWAN RIVERS
AVERAGE MONTHLY FLOWS FOR 1982

Month	North Saskatchewan River at Prince Albert (m^3/s)		South Saskatchewan River below Red Deer River (m^3/s)	
	Recorded	Normal	Recorded	Normal
January	103	130	49	90
February	105	125	58	100
March	93	115	72	130
April	219	340	232	275
May	438	340	242	340
June	292	395	546	640
July	745	395	535	390
August	304	225	164	180
September	205	225	106	130
October	217	210	136	135
November	140	100	93	125
December	129	115	71	110
Average	249	225	192	220

NOTE: Normals shown are based on 1975 level of development in Alberta.

B. FORECASTS

Forecasting procedures developed by Water Survey of Canada for the Prairie Provinces Water Board were employed for forecasting water supply on the Saskatchewan River system in 1982. The 1964 Saskatchewan Water Resources Commission forecasting procedures were used as confirmation. The River Simulating Package (SIMPAK) developed by Environment Canada was also employed for streamflow simulating.

Forecasts were updated monthly and operation plans adjusted as required based on these forecasts. Because future climatic events are unknown and difficult to predict at the time that a forecast is made, each forecast included the following:

1) best estimate - based on recorded precipitation and flows to the first day of the forecast month and normal precipitation to the end of the forecast period;
2) lower quartile estimate - based on recorded precipitation and flows to the first day of the forecast month and lower quartile precipitation to the end of the forecast period; and
3) upper quartile estimate - based on recorded precipitation and flows to the first day of the forecast month and upper quartile precipitation to the end of the forecast period.

These lower and upper quartile values were used in operation planning to assure that plans based on the "best estimate" forecast did not include decisions that would be irreversible if smaller or larger flows were to occur. The forecasts of water supply are summarized in Table 2 and Table 3 for the South Saskatchewan and North Saskatchewan Rivers respectively.

Table 2

SOUTH SASKATCHEWAN RIVER
WATER SUPPLY FORECAST SUMMARY OF
1982 INFLOW TO LAKE DIEFENBAKER

	Flow Forecast Prepared in the Month of:												
Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Recorded
Jan.	60												49
Feb.	80	60											58
Mar.	130	130	120										72
Apr.		320	270	250									232
May		380	330	370	370								242
June		640	630	650	730	670							546
July		420	380	390	390	390	520						535
Aug.		190	170	180	180	180	170	180					164
Sept.		150	130	130	130	130	130	130	100				106
Oct.		140	130	130	130	130	130	120	100	80			136
Nov.										100	120		93
Dec.										100	100	80	71

Note: Numbers in the body of the table show the values forecasted on the first day of the forecast month.
Values in the right hand column are the recorded flows for comparison.

Monthly mean flow (m^3/s)

Table 3

NORTH SASKATCHEWAN RIVER
WATER SUPPLY FORECAST SUMMARY OF
1982 FLOWS AT PRINCE ALBERT

	Flow Forecast Prepared in the Month of:												
Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Recorded
Jan.	120												103
Feb.	140	110											105
Mar.	130	130	130										93
Apr.		360	360	380									219
May		370	370	370	370								438
June		400	400	420	400	350							292
July		380	380	380	340	350	650						745
Aug.		260	260	260	260	260	260	340					304
Sept.		230	230	230	230	230	230	270	190				205
Oct.		190	190	190	190	190	190	200	180	180			217
Nov.										150	150		140
Dec.										140	140	130	129

Note: Numbers in the body of the table show the values forecasted on the first day of the forecast month.
Values in the right hand column are the recorded flows for comparison.

Monthly mean flow (m^3/s)

Chapter III

RESERVOIR DIVERSIONS AND LOSSES

A. GENERAL

For the purposes of this report, only diversions and losses that remove water from the Saskatchewan River system in Saskatchewan are considered. Diversions and losses from Lake Diefenbaker include the East Side Pumping Plant, the Qu'Appelle River Dam releases and evaporation. At Tobin Lake, evaporation losses are calculated however no analysis has been made on the residuals from the water balance. Withdrawals from above and below the lakes for irrigation and water supply are considered to be negligible.

B. EAST SIDE PUMP PLANT

Water is withdrawn from Lake Diefenbaker by Saskatchewan Agriculture through its pumping facilities near the east end of Gardiner Dam. This water is used for irrigation in the Outlook area and to supply industrial, municipal and other users through the Saskatoon Southeast Water Supply System. Figure 11 shows the locations of these users.

Table 4 summarizes withdrawals through the East Side Pump Plant for the years 1967 to 1982.

C. QU'APPELLE RIVER DAM RELEASES

Water supply requirements on the Qu'Appelle River system for municipal, industrial, recreation, irrigation and other uses may be

Table 4

1982 AND HISTORIC (1967-81)
WITHDRAWALS THROUGH EAST SIDE PUMP PLANT

Year	Pumped Quantity (Dam^3)								Annual Total Dam^3
	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	
1967	0	0	0	15 240	19 580	20 190	21 640	10 110	86 760
1968	0	1 650	8 040	11 840	940	80	0	0	22 550
1969	0	4 310	12 880	6 030	2 210	1 190	0	0	26 620
1970	0	710	2 560	6 540	2 170	480	20	0	12 480
1971	0	4 450	5 260	8 700	2 480	2 900	1 230	0	25 020
1972	0	7 820	8 940	13 500	11 200	9 070	1 130	0	51 660
1973	8 240	7 610	11 790	13 260	13 260	12 000	300	0	66 460
1974	0	0	5 130	13 120	5 090	250	3 780	0	27 370
1975	0	6 700	12 030	17 060	7 450	9 410	0	0	52 650
1976	0	7 450	8 970	12 050	13 100	1 860	0	0	43 430
1977	0	11 460	16 800	33 750	14 330	11 150	0	0	87 490
1978	0	10 290	21 640	27 860	16 390	12 340	0	0	88 520
1979	0	410	9 030	28 300	16 730	9 250	0	0	63 720
1980	0	16 850	26 650	35 420	16 280	15 650	0	0	110 850
1981	0	20 300	14 860	35 160	16 850	19 610	0	0	106 780
1982	0	12 130	7 780	25 670	14 800	10 230	0	0	70 610
Avg.	520	7 010	10 770	18 970	10 800	8 480	1 760	630	58 940

augmented with releases at the Qu'Appelle River Dam as directed by the Qu'Appelle Operation Board.[2]

Releases were made from the Qu'Appelle River Dam in 1982 to satisfy municipal and other requirements. During the summer months Eyebrow and Buffalo Pound Lakes received water from the Saskatchewan River system; to meet wildlife and municipal requirements at the two lakes, respectively. In total, 38 030 cubic decametres (dam^3) of water was released to the Qu'Appelle River in 1982. This release can be considered somewhat below normal. The monthly distribution of these releases is shown in Table 5.

D. EVAPORATION LOSSES

A detailed study of evaporation from Lake Diefenbaker for 1982 was undertaken by the Atmospheric Environment Service.[3] The evaporation losses that were determined in that study, using Meyer's equation, were combined with precipitation [4] over the reservoir to determine the net evaporation estimates shown in Table 6.

2/ This Board is appointed by the Minister of Saskatchewan Environment and has representation from Saskatchewan Environment, Saskatchewan Tourism and Renewable Resources, Saskatchewan Agriculture, PFRA and the Qu'Appelle Management Board Public Advisory Committee.

3/ R. F. Hopkinson. Temperature and Evaporation on Lake Diefenbaker 1981 and 1982, Hydrometeorological Report No. CSS-R83-01, In Preparation.

4/ Based on the average of the following meteorological stations: Elbow, Glenside, Herbert, Strongfield, Swift Current, Tugaske, Pennant and Shackleton.

Table 5

1982 AND HISTORIC (1967-81)
QU'APPELLE RIVER DAM RELEASES

Year	Monthly Releases (Dam^3)												Annual Total (Dam^3)
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
1967	0	0	0	70	50	3 430	12 210	15 450	13 370	14 980	15 350	13 590	88 500
1968	12 530	4 350	1 950	5 300	9 550	11 840	11 950	1 360	80	70	18 440	11 720	89 140
1969	11 770	2 500	0	0	40	50	7 060	4 160	10 700	1 250	6 540	7 540	51 610
1970	0	0	0	50	60	90	90	90	100	430	7 230	7 140	15 280
1971	4 290	3 080	280	60	620	80	110	1 440	260	3 860	6 650	3 790	24 520
1972	3 790	2 860	460	130	12 450	9 480	16 520	10 650	2 830	1 580	8 700	3 790	73 240
1973	3 790	230	650	14 170	17 060	3 400	14 760	15 980	1 720	5 480	4 380	3 490	85 110
1974	3 320	770	90	120	150	120	530	1 610	110	110	8 940	4 930	20 800
1975	3 790	2 890	90	110	110	1 050	2 510	5 250	5 810	4 260	4 340	4 250	34 460
1976	4 090	930	140	150	320	520	1 330	2 100	7 080	3 750	4 530	4 030	28 970
1977	2 860	2 700	3 060	3 210	9 850	9 940	8 190	9 250	8 710	8 850	3 890	3 280	73 790
1978	3 240	2 280	180	130	1 400	2 310	7 200	10 280	9 760	5 030	3 420	3 550	48 780
1979	3 340	2 850	60	100	290	740	2 880	8 820	9 620	4 600	3 630	3 420	40 350
1980	3 400	3 030	280	260	3 890	17 370	19 010	15 440	10 070	4 660	4 660	4 970	87 040
1981	4 750	2 680	2 070	10 370	25 920	27 130	26 960	22 030	12 360	1 560	2 940	3 370	142 140
1982	3 350	3 090	2 100	90	90	1 200	2 590	4 350	7 690	5 310	4 530	3 640	38 030
Avg.	4 270	2 140	710	2 140	5 120	5 550	8 370	8 020	6 270	4 110	6 760	5 410	58 860

Table 6

1982
SUMMARY OF WATER BALANCE FOR LAKE DIEFENBAKER

Months	Inflow		Outflow			Change in Storage		Difference
	South Sask. River	Local	Net Evaporation	Total Diversions	Outflow South Sask. River	From Water Balance	From Change in Water Elevation	
January	132 620	520	0	10 890	885 000	-762 750	-755 840	6 910
February	141 350	600	0	9 940	728 610	-596 600	-612 190	-15 590
March	195 350	29 550	0	9 680	640 570	-425 350	-381 720	43 630
April	603 330	114 310	1 210	7 430	400 550	308 450	387 770	79 320
May	650 680	7 430	-21 080	19 790	214 700	444 700	363 750	-80 950
June	1 417 740	8 290	19 350	16 330	122 430	1 267 920	1 142 740	-125 180
July	1 433 380	7 080	17 630	35 860	136 680	1 250 290	1 078 320	-171 970
August	440 120	3 800	49 160	26 700	232 160	135 900	82 500	-53 400
September	277 080	3 460	46 310	25 230	270 000	-61 000	-101 850	-40 850
October	364 610	3 200	29 120	12 870	364 870	-39 050	-83 340	-44 290
November	242 780	1 640	22 720	11 840	550 200	-340 340	-386 050	-45 710
December	192 070	2 250	-4 230	11 230	665 880	-478 560	-429 600	48 960
Total	6 091 110	182 130	160 190	197 790	5 211 650	703 610	304 490	-399 120

Monthly volume (dam^3)

E. TOTAL DIVERSIONS AND LOSSES AT LAKE DIEFENBAKER

Table 6 provides a month-by-month listing of the inflows to, outflows from and changes in storage at Lake Diefenbaker during 1982. The "difference", in the table represents the difference between change in storage calculated using the water balance, and the change in storage calculated using the apparent change in water level.

If all the measurements in the water balance were precise, the difference would have to be the ground water gain or loss factor. Lake Diefenbaker raised the water level in 240 kilometres of the South Saskatchewan River Valley by an average of 25 metres. While this rise in water level caused adjustments in the ground water levels in the immediate area, the valley remains a discharge point in the regional ground water regime.[5/] Thus, charging the overall loss of water (399 120 dam^3) to ground water must be rejected and other explanations for the difference must be identified.

The simplest explanation would be that the annual differences are a net result of measurement error. This 399 120 dam^3 would require less than 7 per cent error in the flow record. Since this difference resulted from a balance of inflow and outflow it would represent about 3 per cent error in each component. Hydrometric data collection agencies would accept that as a good standard of accuracy. Since two components of the water balance, evaporation and precipitation, were arrived at by indirect calculations, a greater error could be

5/ Van Everdingen, R.O., 1972, Observed changes in Ground Water Regime Caused by the Creation of Lake Diefenbaker, Saskatchewan, Inland Waters Branch, Department of the Environment, Ottawa.

assigned to these and the flow measurement portion of the balance could be considered better than 7 per cent accurate.

The monthly differences are less easily accommodated; they are too large to be explained by climatic and hydrometric measurement error alone. It has been concluded that the storage factor used in the water balance may be too small because:

1) the reservoir could be slightly larger than the capacity curve suggests, particularly at the upper levels of the shoreline where erosion has taken place; and
2) bank storage, that is, the movement of water into the soils of the reservoir bank while the lake fills and the return of this water as the lake drains, would also create a greater storage capacity than the impervious reservoir assumed for the water balance.

F. MISCELLANEOUS DIVERSIONS FROM THE NORTH AND SOUTH SASKATCHEWAN RIVERS

The Cities of Saskatoon and Prince Albert, Towns such as Outlook and St. Louis and a number of private irrigation schemes in Saskatchewan use the water of the Saskatchewan River system. However, because of return of effluent and the small size of these withdrawals in comparison to total flows, their net effect is quite small. For example, the City of Saskatoon withdraws approximately 1 m^3/s and returns approximately 80 per cent of this as effluent. For that reason these miscellaneous diversions are not considered in this report.

G. TOBIN LAKE LOSSES

Table 7 provides a month-by-month listing of the inflows to, outflows from and change in storage at Tobin Lake during 1982. The "difference" in the table represent the amount by which the surface water balance failed to balance with the apparent change in storage.

A detailed study of evaporation from Tobin Lake for 1982 by the Atmospheric Environment Services[6/] is also considered. The evaporation losses that were determined in that study, using Meyer's equation, were combined with precipitation[7/] over the reservoir to determine the net evaporation estimates.

6/ R. F. Hopkinson. Evaporation from Tobin Lake 1982 Hydrometeorological Report No. CSS-R83-03, April, 1983.

7/ Based on the meteorological station: Nipawin.

Table 7

1982
SUMMARY OF WATER BALANCE FOR TOBIN LAKE

Months	Inflow	Outflow		Change in Storage		Difference
	Saskatchewan River	Net Evaporation	Sask. River	From Water Balance	From Change in Water Elevation	
January	1 177 370	0	1 322 700	-145 330	56 605	201 980
February	1 058 230	0	1 200 610	-142 380	-42 480	99 900
March	900 630	0	1 254 180	-353 550	-284 220	69 330
April	970 010	0	1 193 440	-223 430	104 370	327 800
May	1 588 900	-20 650	1 381 450	228 100	257 370	29 270
June	940 980	17 190	1 210 030	-286 240	-282 000	4 240
July	2 085 960	4 750	1 900 630	180 580	241 300	60 720
August	1 147 310	34 210	1 067 990	45 110	46 610	1 500
September	822 960	20 820	807 320	-5 180	-52 270	-47 090
October	993 510	10 970	945 650	36 890	22 720	-14 170
November	869 100	6 910	754 960	107 230	-142 120	-249 350
December	1 076 370	0	892 340	184 030	153 920	-30 110
Total	13 631 330	74 200	13 931 300	-374 170	79 850	454 020

Monthly volume (dam^3)

Chapter IV

GENERATING STATION OPERATION

A. COTEAU CREEK

Ice began to form on the South Saskatchewan River below Gardiner Dam towards the end of November, 1981. Flows were increased to between 200 m^3/s and 300 m^3/s in mid-November, 1981. Flows near 250 m^3/s with restrictions on fluctuations to allow for a safe freeze up operation, were implemented during mid-December, 1981. Early in January, 1982, a winter operation plan was implemented and stayed in effect until April, 1982.

With a normal mountain snowpack, and a reservoir elevation of 548.97 m on May 1, 1.76 m below normal, outflows were reduced to 80 m^3/s by May 1, 1982, and further reduced to near 50 m^3/s by the end of May, 1982. Precipitation of 10 mm to 90 mm from July 1-5, 1982, in southern Alberta helped boost total precipitation for spring and summer to near normal and produced additional runoff. Releases from Lake Diefenbaker remained near 50 m^3/s until the beginning of August when full supply level was being approached. Releases were then increased to the 100 m^3/s range.

Lake Diefenbaker elevation crested in late August at elevation 556.15 metres, 0.72 metres below FSL. Starting mid-November SPC released flows between 200 m^3/s and 250 m^3/s without slugging restrictions but with daily change restrictions. Towards the end of November freeze

up operations in the 260 m^3/s range began with restrictions on hourly and daily fluctuations. In early January, 1983, freeze up was judged adequate to go into full winter operation.

On December 31, 1982, the elevation of Lake Diefenbaker was 553.59 metres, compared to 552.73 metres, January 1, 1982. Inflow, outflow and lake elevations are shown graphically on Figure 9. Table 8 shows the mean monthly outflows from Lake Diefenbaker at Gardiner Dam for the period 1969 to 1982.

B. SQUAW RAPIDS

Operations throughout the year were quite normal and spillway use was not necessary. In December there were some complaints from residents at Cumberland House concerning water on the river ice which is used as access to the community. Daily mean releases from Squaw Rapids varied from less than 200 m^3/s to over 400 m^3/s within a few days causing water to go onto the river ice at Cumberland House crossing. A winter road was built across the ice to Cumberland House but with the rise and fall of the water the approaches would break away at the shore lines. The Saskatchewan Power Corporation was requested to hold daily mean releases to a more constant rate. This steady flow combined with the use of temporary wooden approaches alleviated the problem.

Flows on the North Saskatchewan River were 130% of normal through the summer while flows on the South Saskatchewan River were normal. The Saskatchewan River consequently had normal summer flows.

Table 8

MEAN MONTHLY RELEASES FROM
GARDINER DAM

Year	Mean Monthly Release - m^3/s												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Aug.
1969	358	368	334	266	308	284	777	207	176	186	259	341	322
1970	370	319	156	107	123	188	179	172	149	211	232	326	211
1971	359	384	323	255	242	342	110	76	78	123	272	341	242
1972	325	296	349	286	197	315	444	305	232	211	264	360	299
1973	366	346	197	92	84	134	120	104	164	114	226	292	187
1974	346	308	337	306	324	489	265	199	172	129	210	274	280
1975	329	322	218	123	204	568	366	123	102	199	254	324	261
1976	363	336	240	137	68	60	69	215	209	200	226	347	206
1977	361	245	101	62	44	45	44	45	44	52	186	223	121
1978	220	178	161	115	55	250	150	123	235	212	219	233	179
1979	333	345	267	93	156	158	59	65	45	120	153	182	165
1980	241	324	162	83	56	154	106	45	88	155	236	262	159
1981	303	264	150	157	152	491	360	466	246	193	220	230	269
1982	330	301	239	154	80	47	51	86	104	136	212	248	166
Average	329	310	231	160	150	252	221	159	146	160	226	285	219

The inflow, outflow and lake elevations are shown graphically on Figure 12.

C. ENERGY GENERATED

The amount of energy generated is usually a function of the magnitude of flow in the Saskatchewan River system. In 1982 power generation at Coteau Creek was considerably less than in 1981 because of lower inflows to Lake Diefenbaker. As well, Squaw Rapids generated less power in 1982 than in 1981. Table 9 shows the comparative power generation levels for recent years. The monthly distribution of generation in 1982 is shown in Table 10. The water rental paid in 1982 by the Saskatchewan Power Corporation to the province was $272,766 for Coteau Creek and $420,146 for Squaw Rapids.

Table 9

SASKATCHEWAN RIVER SYSTEM
ANNUAL POWER GENERATION IN RECENT YEARS

Year	Energy at Coteau Creek (MWH)*	Energy at Squaw Rapids (MWH)
1968	200 900	790 000
1969	1 123 800	1 236 200
1970	823 500	1 047 300
1971	900 900	1 166 400
1972	1 131 600	1 243 600
1973	733 700	1 005 100
1974	1 074 000	1 363 100
1975	978 700	1 077 800
1976	836 600	935 400
1977	469 100	807 800
1978	726 800	1 040 000
1979	676 700	925 800
1980	667 300	1 023 800
1981	1 042 600	1 227 200
1982	663 200	1 021 600
Avg.	803 300	1 060 700

* MWH - Megawatt-hours

Table 10

1982 MONTHLY DISTRIBUTION OF
SASKATCHEWAN RIVER SYSTEM POWER GENERATION

Month	Coteau Creek Generating Station (MWH)*	Squaw Rapids Generating Station (MWH)
January	109 490	90 630
February	86 390	89 490
March	71 840	89 690
April	44 730	89 060
May	26 000	92 080
June	15 620	88 480
July	18 510	144 950
August	32 680	76 920
September	38 060	61 160
October	51 630	74 590
November	76 750	54 600
December	91 500	69 950
TOTAL	663 200	1 021 600

* MWH - Megawatt-hours

Chapter V

SPECIAL CONDITIONS

A. GENERAL

The preceeding chapters describe the operation of the Saskatchewan River system in general terms and indicate overall monthly operation characteristics.

Some special conditions occurred which had to be dealt with during the year. Water supply forecasting and long-term operation planning is supplemented with shorter-term operation planning. The agencies involved in planning operations monitor flows and water use on a week-to-week basis and during critical periods on a day-to-day basis. The following sections describe those periods in 1982 when the day-to-day operation planning dealt with special conditions.

B. RAIN STORMS

A heavy snowstorm at the end of May in southeastern Alberta and southwestern Saskatchewan resulted in snow accumulations of up to 55 cm. Inflow to Lake Diefenbaker increased to over 400 m^3/s, but with the precipitation coming as snow the melt allowed for a lengthy runoff time period.

Rain storms near the end of June and the beginning of July resulted in 50 mm to 150 mm of precipitation over the southern half of Alberta. Flows in the North Saskatchewan River rose to near 1 700 m^3/s and near 1 000 m3/s in the South Saskatchewan River. Releases from Tobin Lake

were incresed to near 980 m^3/s through the power plant but use of the spillway was not necessary. More minor rains came in July but no major events happened for the rest of the season.

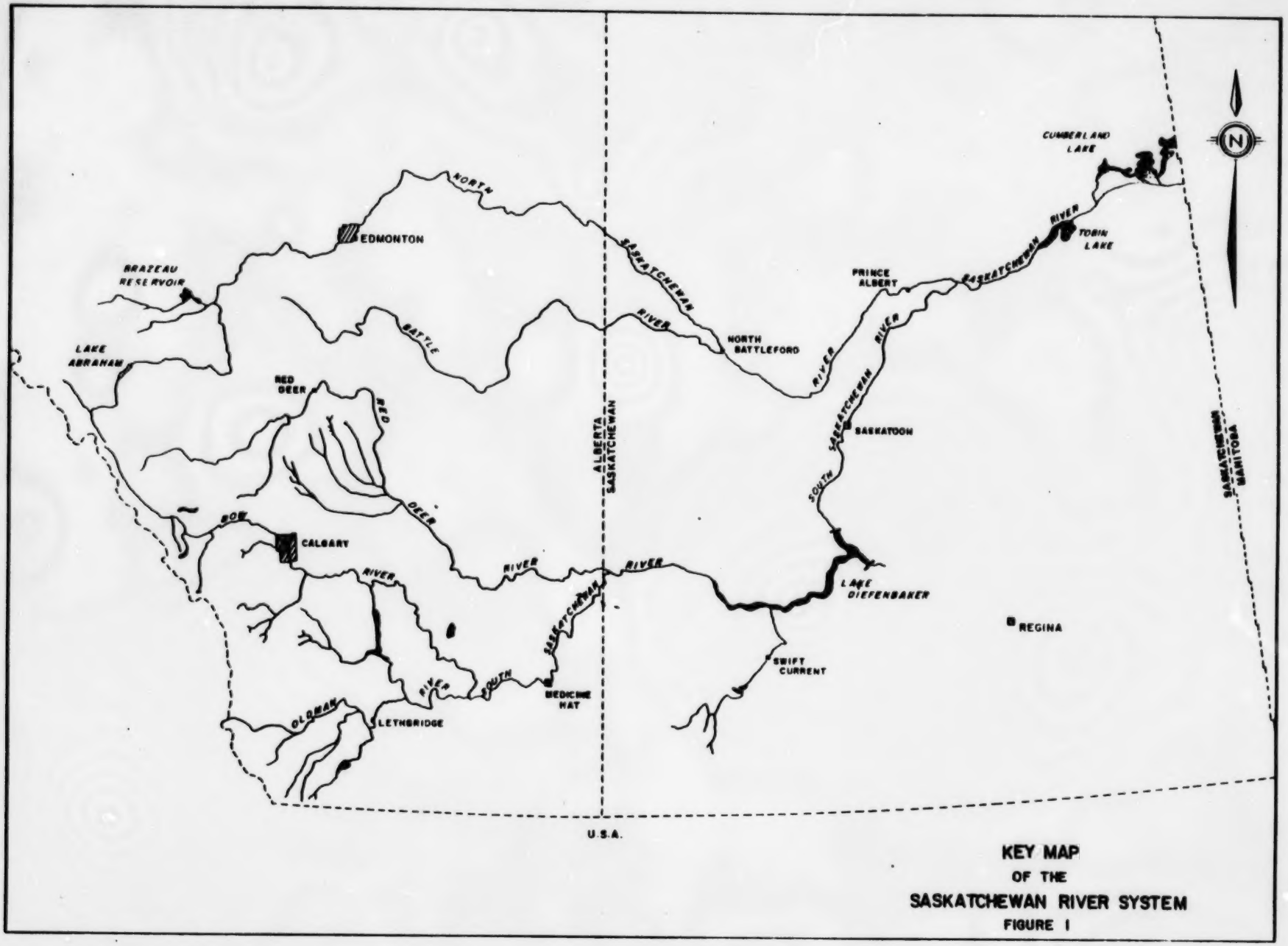
C. SPILLWAY USE

As a result of operation planning, it was possible to operate both Lake Diefenbaker and Tobin Lake without spilling.

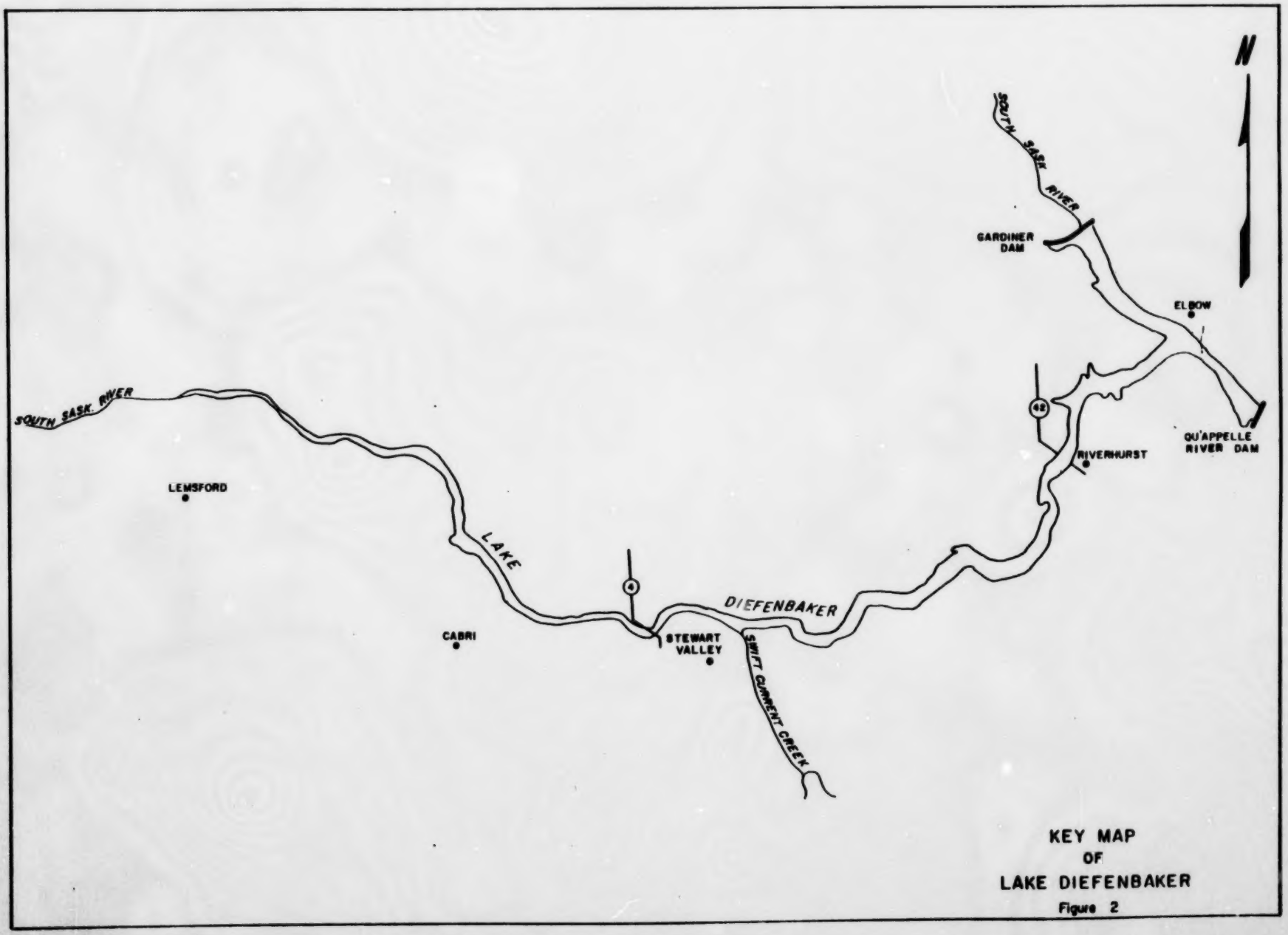
D. FLOOD CONTROL

In 1982, the flood control benefit was of some significance in the operation of Lake Diefenbaker and Tobin Lake. On the South Saskatchewan River below Lake Diefenbaker the maximum daily flow without regulation would have been approximately 1 000 m^3/s. The recorded maximum was 375 m^3/s; approximately 40 per cent of the estimated unregulated peak. On the Saskatchewan River below Tobin Lake the unregulated flow would have been about 2 200 m^3/s, rather than the recorded maximum of 980 m^3/s or 45 per cent of the estimated unregulated peak flows. Figures 13 and 14 show the flow patterns that occurred below the reservoirs as compared to what would have occurred without regulation.

FIGURES

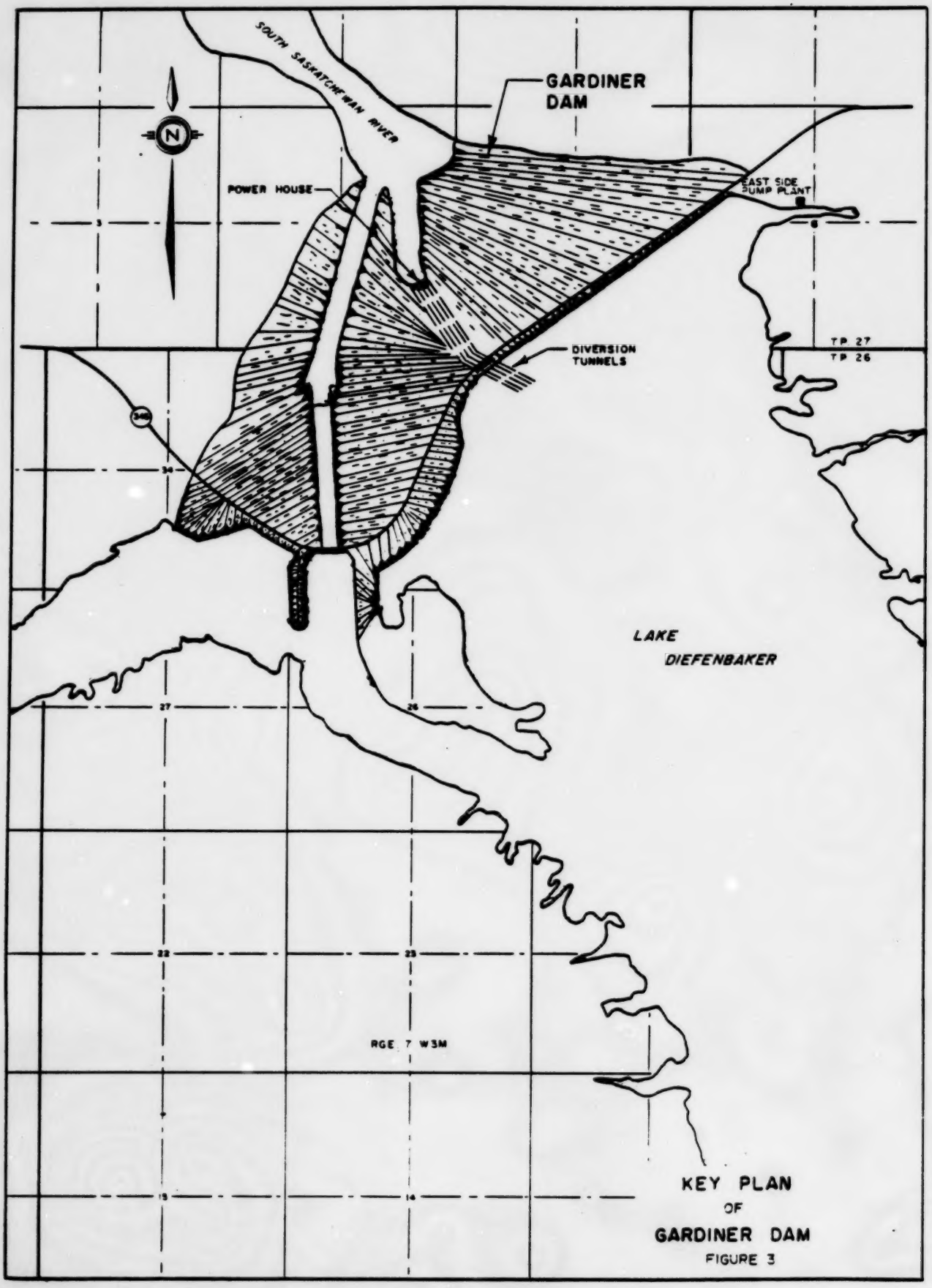


KEY MAP
OF THE
SASKATCHEWAN RIVER SYSTEM
FIGURE 1



KEY MAP
OF
LAKE DIEFENBAKER

Figure 2


SOUTH SASKATCHEWAN RIVER
GARDINER DAM
POWER HOUSE
EAST SIDE PUMP PLANT
DIVERSION TUNNELS
TP 27
TP 26
LAKE DIEFENBAKER
RGE 7 W3M
KEY PLAN
OF
GARDINER DAM
FIGURE 3

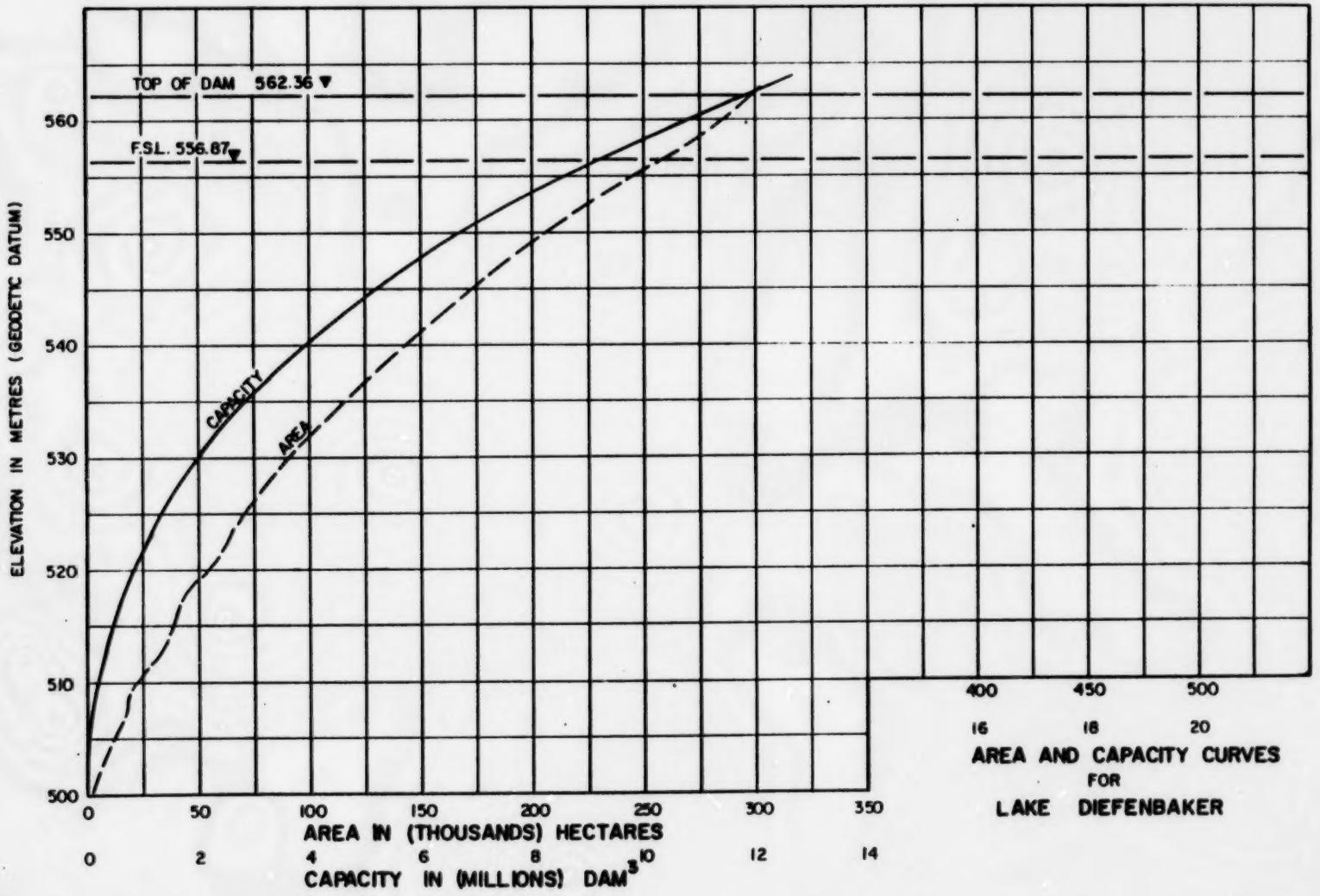
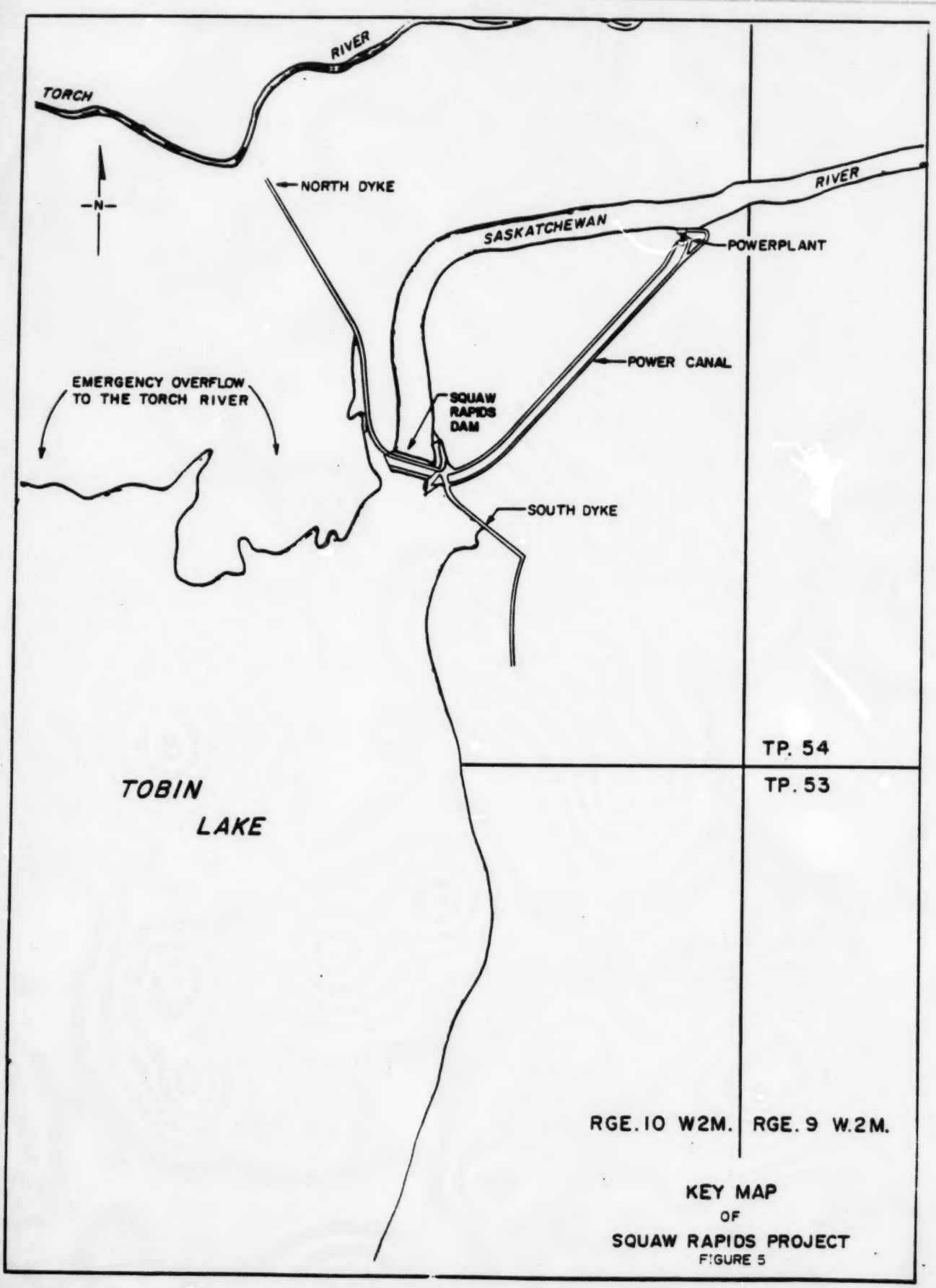
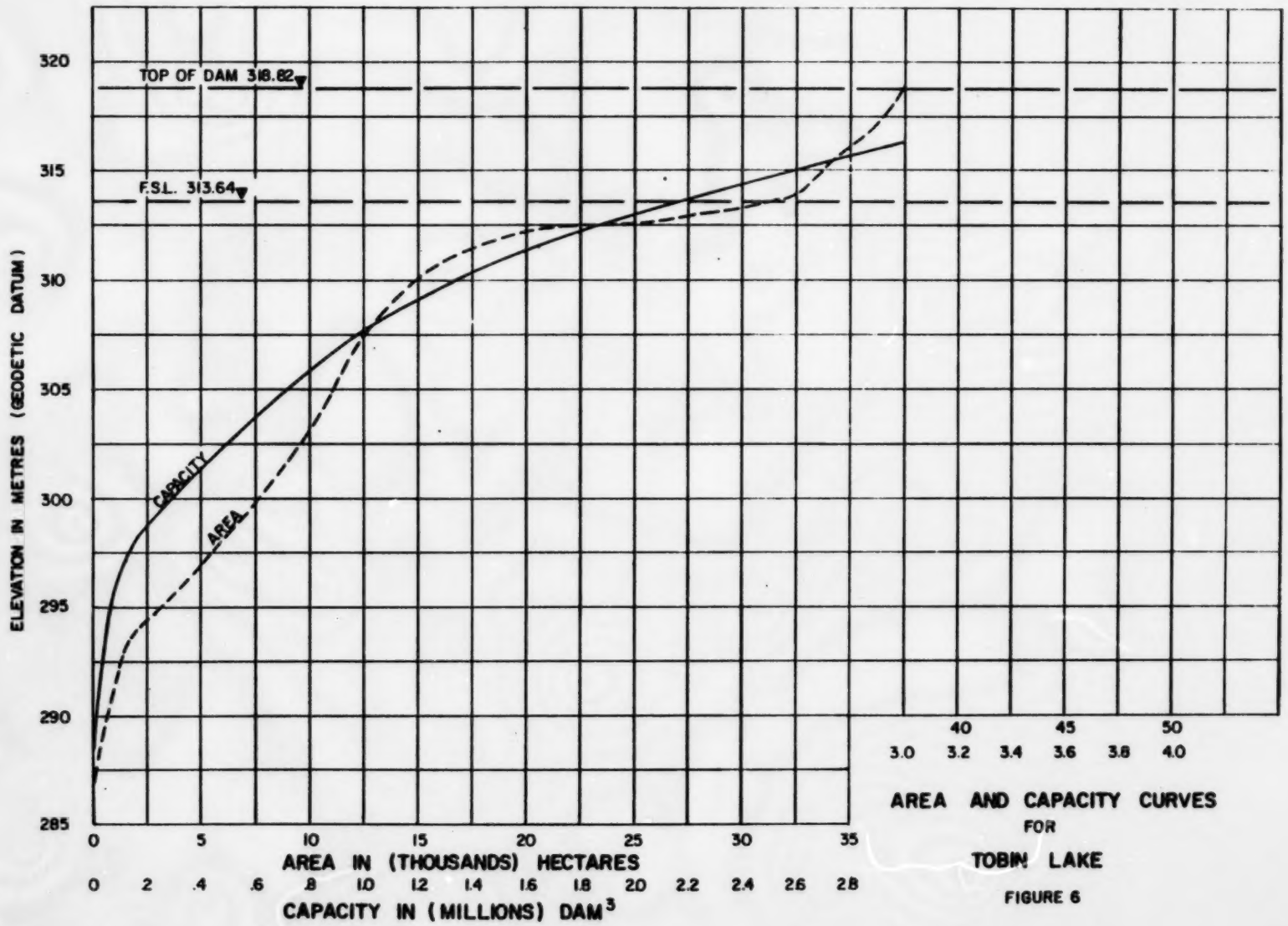

TOP OF DAM 562.36
F.S.L. 556.87
CAPACITY
AREA
ELEVATION IN METRES (GEODETIC DATUM)
500
510
520
530
540
550
560
0
50
100
150
200
250
300
350
AREA IN (THOUSANDS) HECTARES
0
2
4
6
8
10
12
14
CAPACITY IN (MILLIONS) DAM3
400
450
500
16
18
20
AREA AND CAPACITY CURVES
FOR
LAKE DIEFENBAKER

FIGURE 4

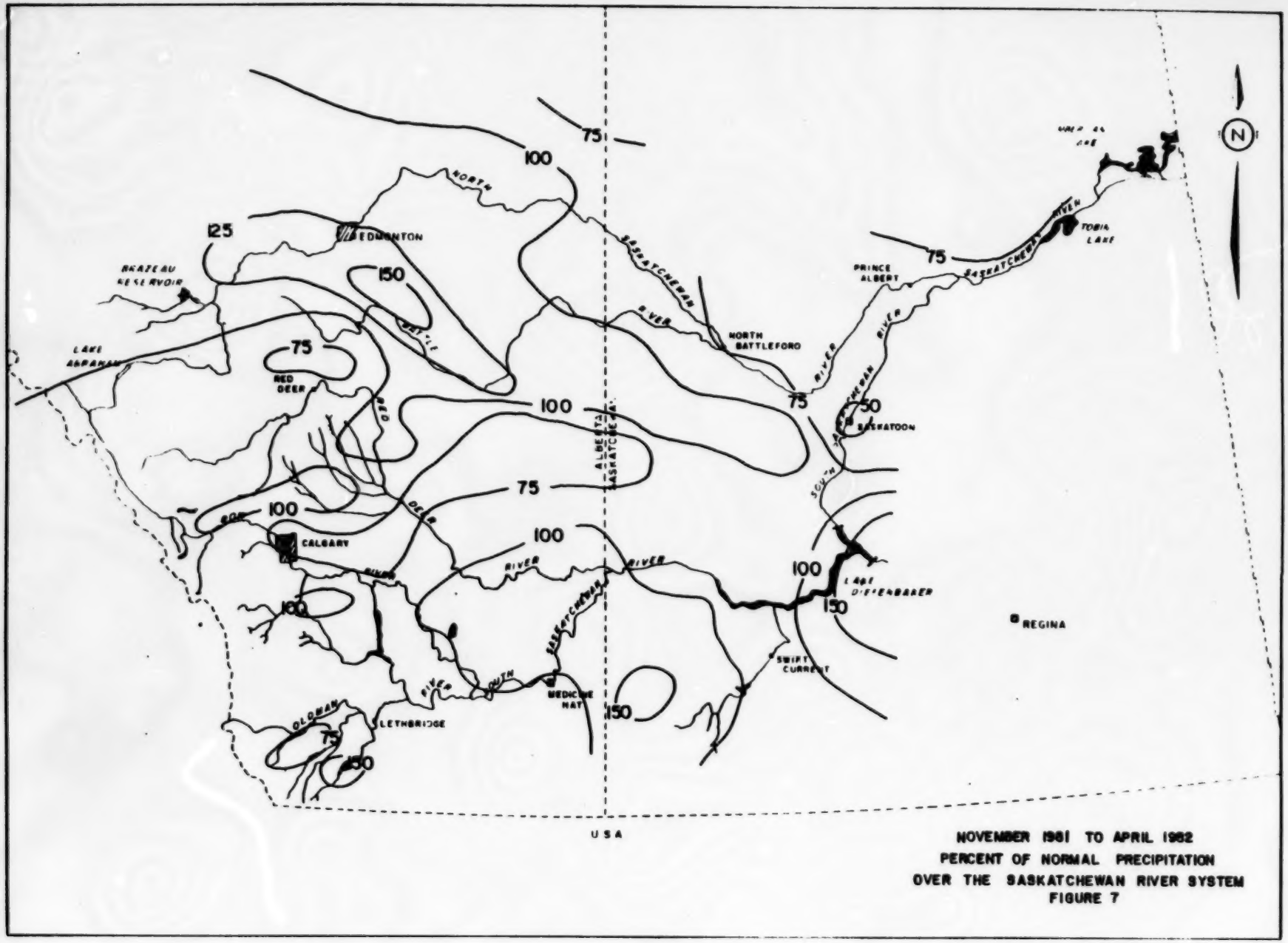


KEY MAP
OF
SQUAW RAPIDS PROJECT
FIGURE 5

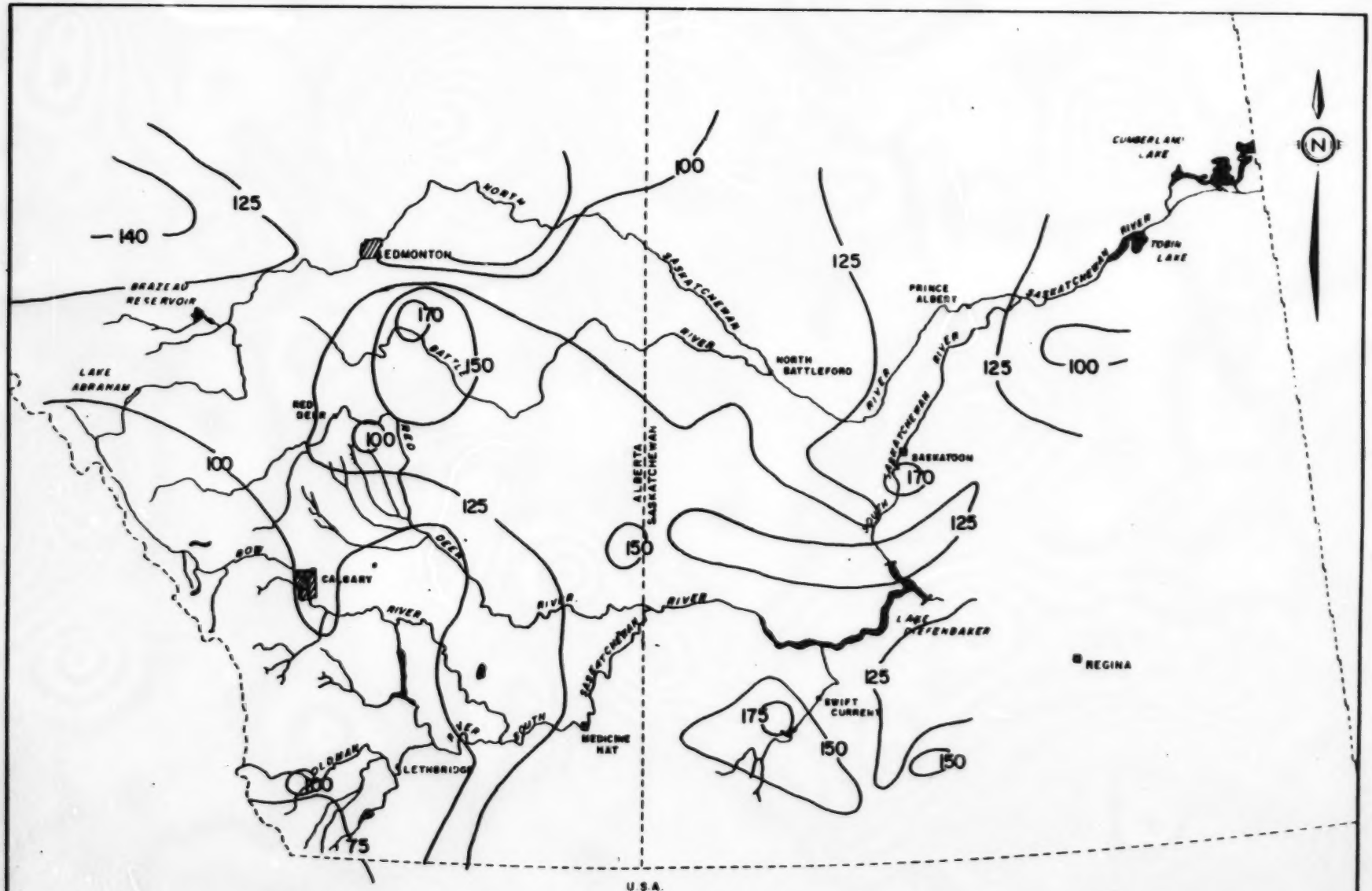


AREA AND CAPACITY CURVES
FOR
TOBIN LAKE

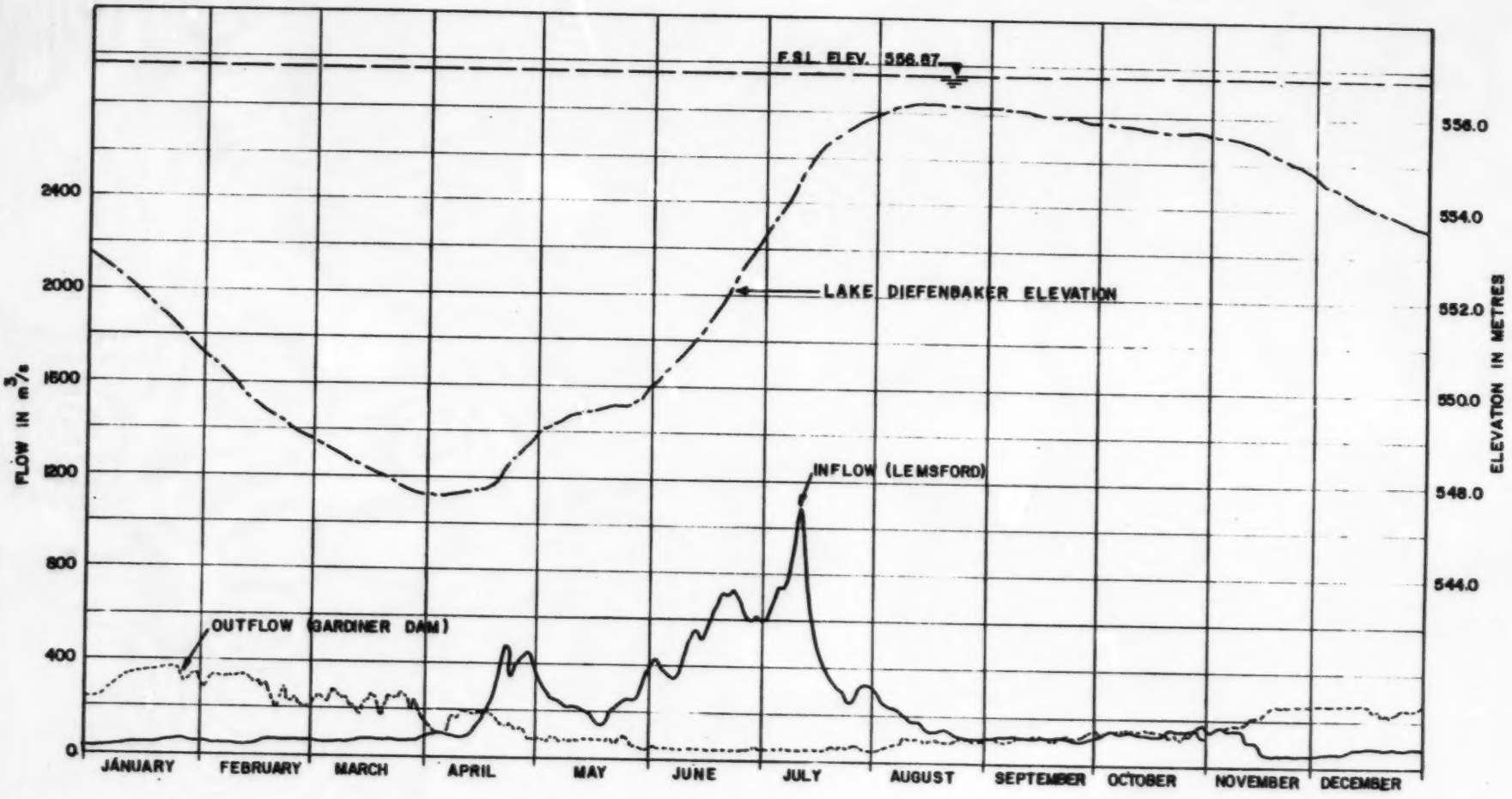
FIGURE 6



NOVEMBER 1981 TO APRIL 1982
PERCENT OF NORMAL PRECIPITATION
OVER THE SASKATCHEWAN RIVER SYSTEM
FIGURE 7



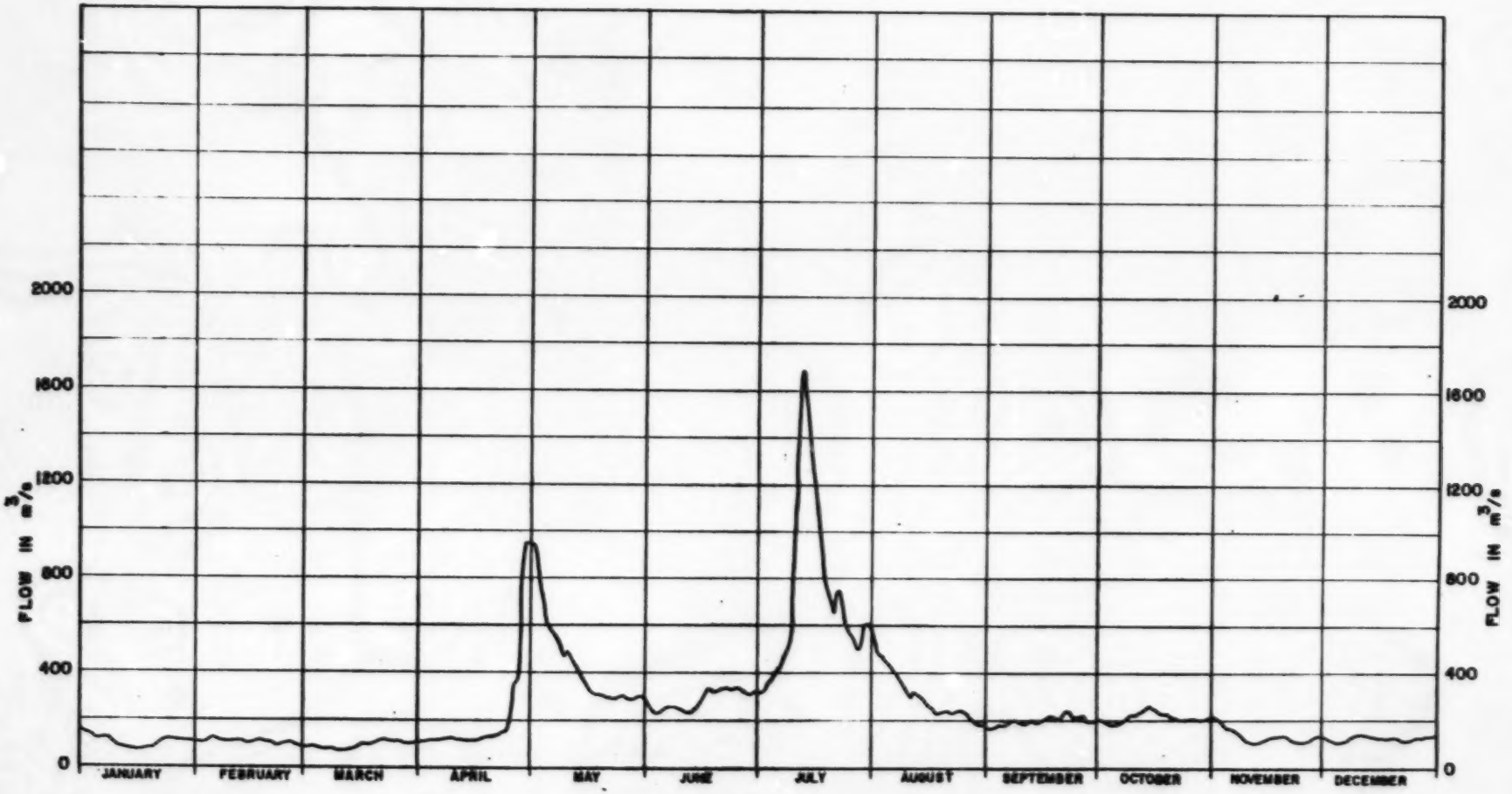
MAY TO OCTOBER 1962
PERCENT OF NORMAL PRECIPITATION
OVER THE SASKATCHEWAN RIVER SYSTEM
FIGURE 8



LAKE DIEFENBAKER
1982
INFLOW-OUTFLOW
AND
LAKE ELEVATION

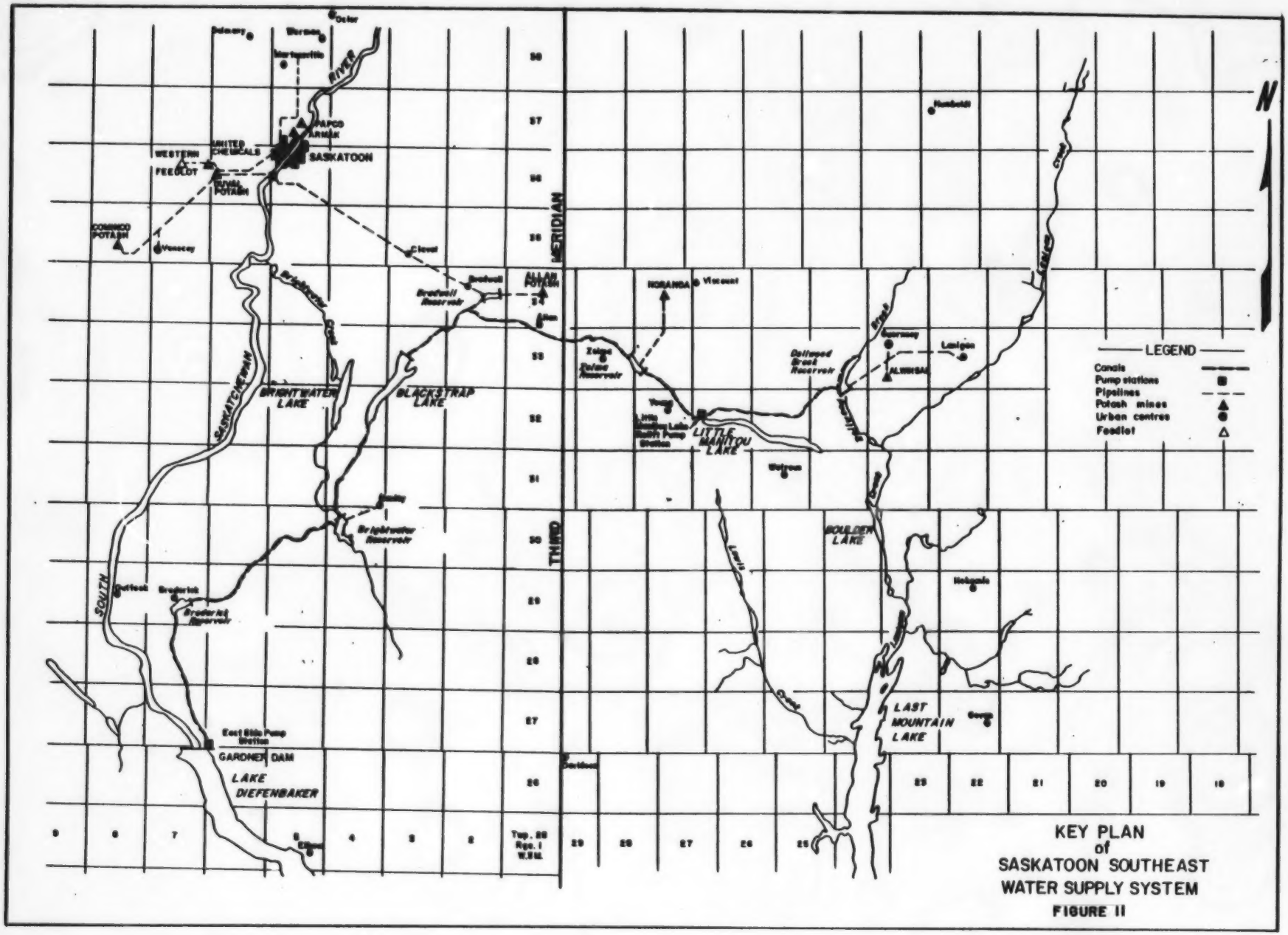
FIGURE 9

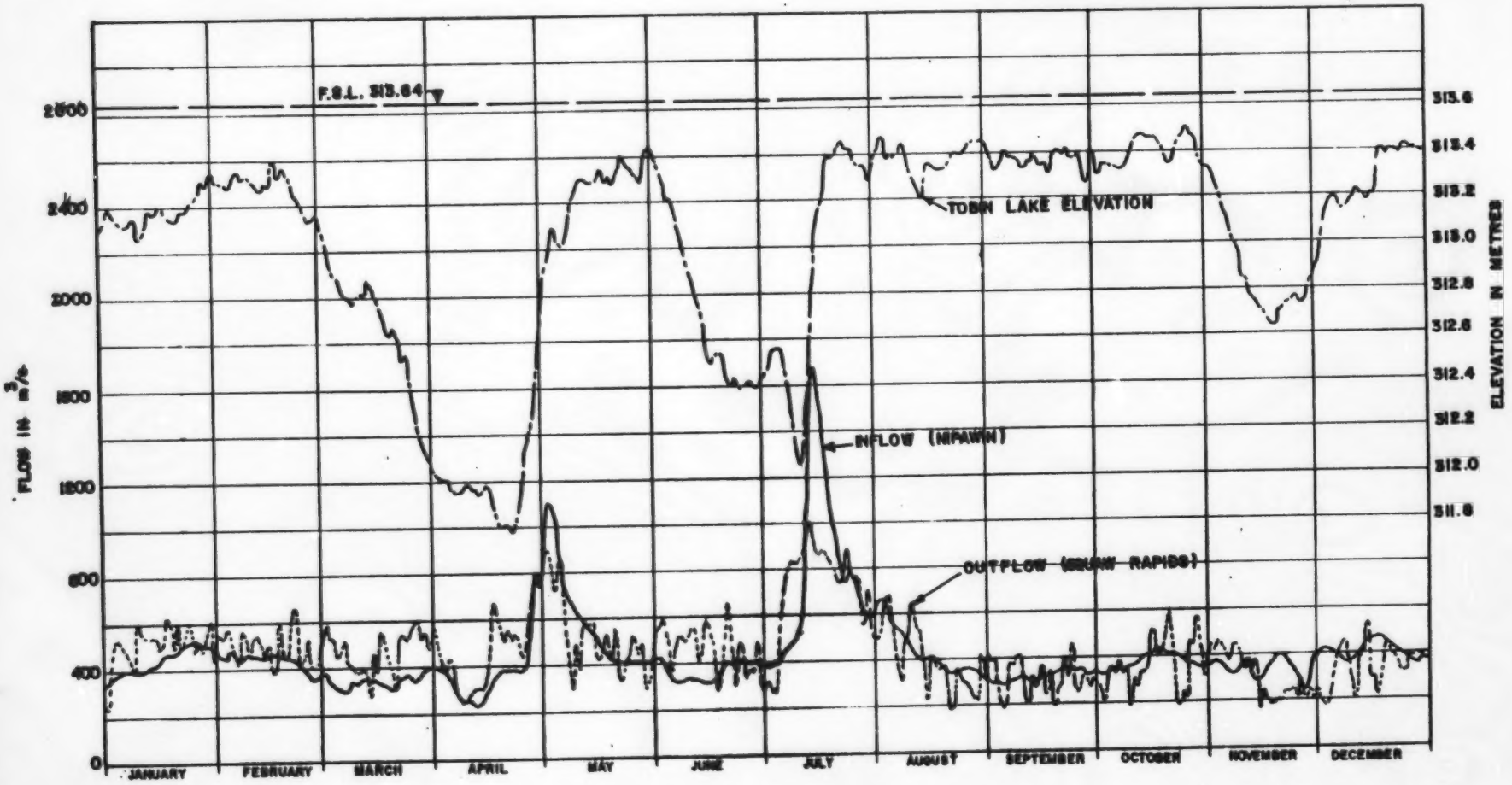
05-00-6



NORTH SASKATCHEWAN RIVER
1982
PRINCE ALBERT
HYDROGRAPH
FIGURE 10

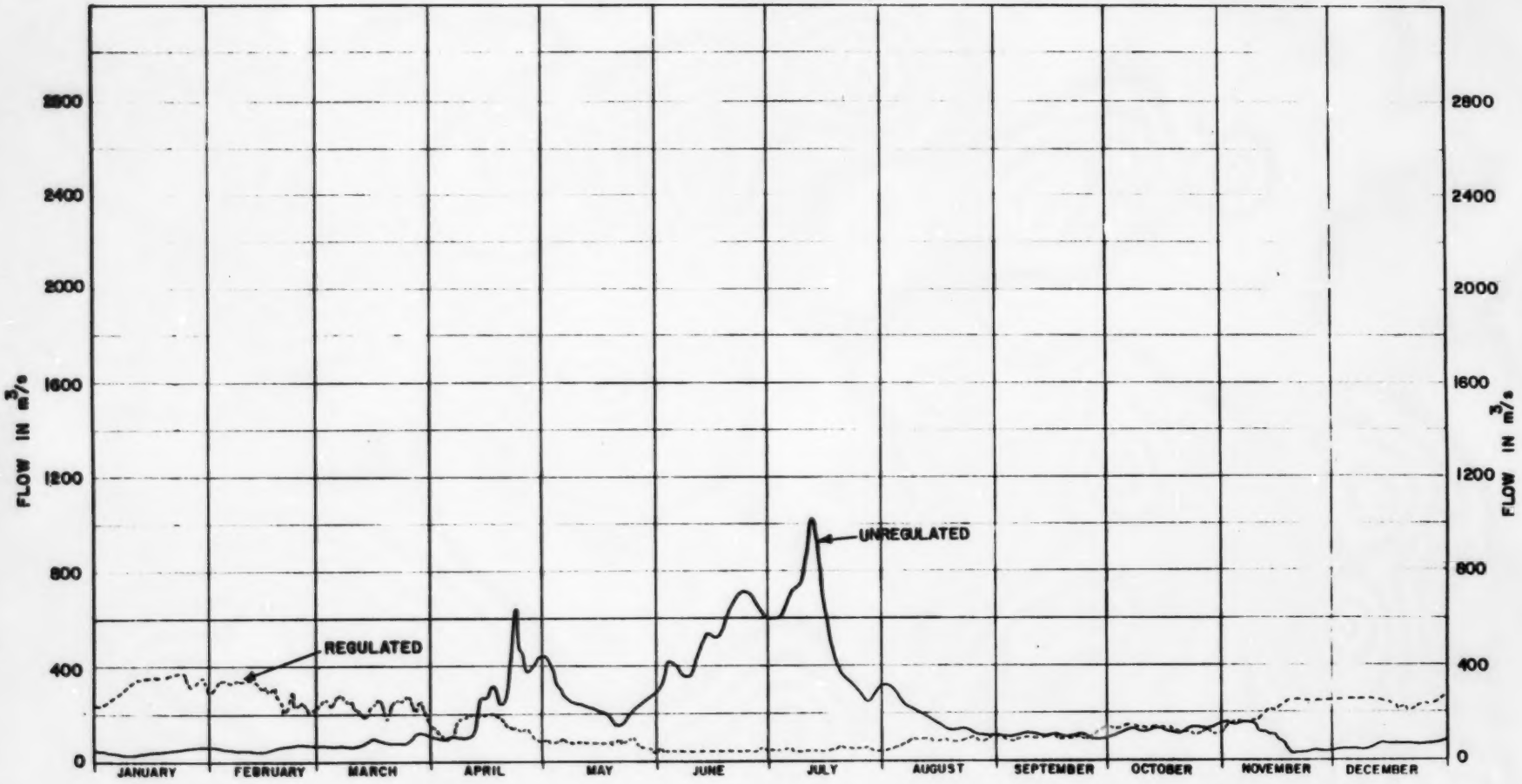
8-80-85


SASKATOON
WESTERN FEEDLOT
UNITED CHEMICALS
ESSO POTASH
COMINCO POTASH
ALLAN POTASH
BRIGHTWATER LAKE
BLACKSTRAP LAKE
SASKATCHEWAN
SOUTH
Bradwell Reservoir
Brightwater Reservoir
Bradwell Brightwater Creek
Brightwater Creek
Bradwell Reservoir
Brightwater Reservoir
East Side Pump Station
GARDINER DAM
LAKE DIEFENBAKER
THIRD MERIDIAN
Tp. 29 Rge. 1 W.3rd
NORANDA
Zelma Zelma Reservoir
Young
Little Manitou Lake South Pump Station
LITTLE MANITOU LAKE
Dalmeyd Brook Reservoir
Dalmeyd Brook
Watrous
Lanigan
ALLANDALE
Lenore
Lenore Creek
Lenore Canal
BOULDER LAKE
Lanigan Creek
Humboldt
Holdfast
LAST MOUNTAIN LAKE
George
LEGEND
Canals
Pump stations
Pipelines
Potash mines
Urban centres
Feedlot
N
KEY PLAN
of
SASKATOON SOUTHEAST
WATER SUPPLY SYSTEM
FIGURE II



TOBIN LAKE
1982
INFLOW, OUTFLOW
AND
LAKE ELEVATION
FIGURE 12

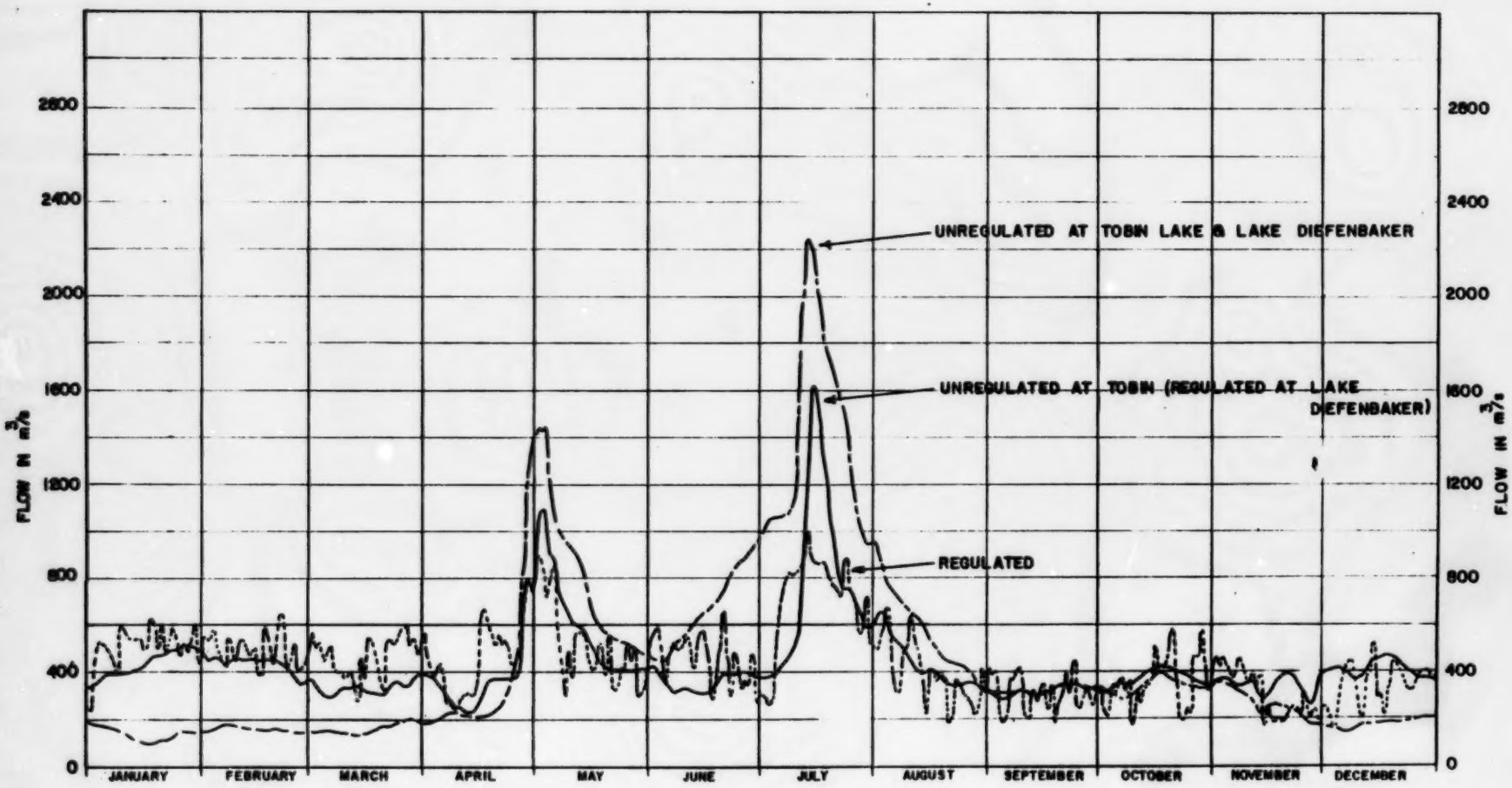
05-00-00-8



EFFECT OF LAKE DIEFENBAKER REGULATION
DURING 1982
ON
SOUTH SASKATCHEWAN RIVER FLOWS
AT CUTBANK

FIGURE 13

8-00-00-80



EFFECT OF REGULATION
DURING 1982
AT LAKE DIEFENBAKER & TOBIN LAKE
ON FLOWS IN THE
SASKATCHEWAN RIVER BELOW SQUAW RAPIDS
FIGURE 14

E-8-00-50

APPENDIX A

HISTORICAL DEVELOPMENT AND OPERATING CRITERIA FOR THE SASKATCHEWAN RIVER SYSTEM

Table of Contents

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APPENDIX A

A. INTRODUCTION

The Saskatchewan River system in Saskatchewan is free flowing except for two major reservoirs, Lake Diefenbaker and Tobin Lake. This text is a documentation of the system's development to date and operating criteria. Figure 1 shows a key map of the system.[1/]

B. LAKE DIEFENBAKER DEVELOPMENT

In the period from 1958 to 1967, Canada, through PFRA, and Saskatchewan jointly constructed the Gardiner and Qu'Appelle Dams, creating Lake Diefenbaker. Figure 2 shows the two dams and Lake Diefenbaker.

The cost of the South Saskatchewan project was about $120 000 000. Under a cost-sharing agreement, Saskatchewan financed $25 000 000 and Canada financed the remaining $95 000 000. Canada supervised construction of the works and provided all engineering.

The total cost included $42 000 000 for embankment construction at Gardiner Dam, $37 000 000 for diversion tunnels, $18 000 000 for the spillway, $10 000 000 for the Qu'Appelle River Dam, $3 000 000 for land purchase and clearing and $10 000 000 for access roads, rail relocation, town site and other miscellaneous items. Figure 3 shows the general layout of Gardiner Dam.

1/ All figures referred to in this appendix are contained in the main body of this report.

The cost of the Coteau Creek generating station at Gardiner Dam was not shared and represents an investment by Saskatchewan through the Saskatchewan Power Corporation of about $40 000 000.

Saskatchewan has also invested in works to utilize the water of Lake Diefenbaker for irrigation and for municipal and industrial water supply through the east side pump plant: for the Saskatoon-Southeast Water Supply system, and improvements to the Qu'Appelle River. The consumptive uses of water from Lake Diefenbaker are very important, but in total they utilize only a small fraction of the total flow of the South Saskatchewan River.

Between 1965 and 1969, as construction neared completion, part of the flow of the South Saskatchewan River was stored and the reservoir was slowly filled. A lake was created that covers about 262 000 hectares and contains 9.4 million dam^3 of water. About 188 000 hectares are permanently flooded by about 5.4 million dam^3 of permanent storage, while the remaining 3.9 million dam^3 of volume are available for flow regulation. Curves showing the storage volume and surface area versus elevation are shown on Figure 4.

During the period of filling, flow in the South Saskatchewan River was maintained by releasing water through the diversion tunnels. From September, 1968, these releases were used for power generation at Coteau Creek Generating Station. The three diversion tunnels that have been harnessed for power generation can handle releases of up to 425 cubic metres per second (m^3/s) and can generate 187 500 kilowatts

at peak capacity. When necessary, outflows in excess of the power plant capacity are released through the gated spillway.

Besides the power production, irrigation, municipal and industrial water supply and the Qu'Appelle River water supply benefits, Lake Diefenbaker has become an important recreation center and sport fishing area. The large lake also provides flood control and with careful planning and integrated operation it has greatly increased the economic value of the Squaw Rapids Generating Station.

C. SQUAW RAPIDS DEVELOPMENT

The Squaw Rapids development was completed by the Saskatchewan Power Corporation on the Saskatchewan River a short distance downstream of Nipawin in 1964. Figure 5 shows the general configuration of the development.

This project receives the combined flow of the North and South Saskatchewan Rivers. The reservoir, Tobin Lake, covers 185 000 hectares and has a usable storage capacity of 623 000 dam^3. Considering that the volume of the water flowing at this location is about twice that received at Lake Diefenbaker and the reservoir is substantially smaller, there is a much smaller effect on the seasonal flow patterns caused by this project than by Lake Diefenbaker. This power development is operated as essentially a "run of the river" operation with the storage capacity used to provide short-term flexibility. Use of this storage is planned on a week-to-week or at

most a month-to-month basis rather than on a seasonal or annual basis as at Lake Diefenbaker. Area and storage capacity curves are shown on Figure 6 for Tobin Lake.

Squaw Rapids has eight generating units that can pass up to 1 133 m^3/s and produce 281 000 kilowatts at peak capacity. The spillway is used to pass flows in excess of 1 133 m^3/s when necessary.

Regulated flows on the South Saskatchewan River as a result of Lake Diefenbaker greatly enhance the economic importance of Squaw Rapids Generating Station for power generation. Since water that is used at Coteau Creek Generating Station flows to Squaw Rapids, it is available for a second use a few days after leaving Lake Diefenbaker. Planning of operation at Coteau Creek must, therefore, take into account this second use and operations of the two generating stations must be closely co-ordinated.

Two power reservoirs in Alberta, Brazeau Reservoir and Lake Abraham, have improved flow patterns of the North Saskatchewan River for power generation in Saskatchewan. Brazeau Reservoir was first operated in 1961 and the Big Horn Dam forming Lake Abraham was completed in 1972. These Alberta reservoirs control only a portion of the headwaters of the North Saskatchewan River, but they have greatly increased the winter flows and thereby added to the usefulness of Squaw Rapids for meeting peak winter power demands.

Although it was built as a reservoir for a hydroelectric generating station, Tobin Lake has developed into a recreation area and also provides some flood control to the Cumberland Lake area and areas downstream in Manitoba.

D. OPERATING GROUND RULES

Criteria for operation of the Saskatchewan River system have been developed. These criteria provide general guidelines for operation, but they leave ample flexibility to accommodate changing conditions.

1. Lake Diefenbaker Levels

Lake Diefenbaker was constructed to accommodate surface water elevations as low as 545.6 metres and as high as 556.8 metres. Water levels cannot be lowered below 545.6 metres because the dams are only protected by riprap down to 545 metres and lower water levels could undermine this slope protection and damage the dams. Elevation 556.8 metres is the upper limit of normal operation and provides adequate freeboard for the safety of the dams.

In order to accommodate recreation use of the lake, it has generally been accepted that elevations in excess of 555.3 metres should be maintained through July and August (whenever the water supply is adequate).

2. Tobin Lake Levels

The upper operating level is 313.6 metres; if this level is exceeded by more than 0.3 m water spills north out of the

reservoir into the Torch River. The normal lower operating limit is 311.5 metres because the channel that carries water to the power plant begins to lose flow capacity if lower levels occur.

3. Lake Diefenbaker Outflow to the Qu'Appelle River

The Qu'Appelle River Dam conduit can release a maximum of 74 m^3/s at full capacity, however, the Qu'Appelle River can only carry 11 m^3/s and therefore this has been the limit on releases from the Qu'Appelle River Dam.

4. Lake Diefenbaker Releases to the South Saskatchewan River

Releases at Gardiner Dam take two forms. Most of the releases are made through the hydroelectric turbines at the Coteau Creek Generating Station which can release up to 425 m^3/s. When releases greater than 425 m^3/s are necessary, the spillway gates have to be opened.

During planning and construction of the South Saskatchewan River project, intensive studies were carried out to determine downstream flow requirements. It was found that all the water intakes for water supply could be modified to accommodate flows as low as 42.5 m^3/s without major expenditures and that the ferry crossings could also be modified to permit operation at this flow. Actual water use on the South Saskatchewan River below Lake Diefenbaker totals less than 3 m^3/s. Pollution regulations are

such that 42.5 m^3/s would be adequate for dilution of sewage effluent. Although even a lower minimum flow would have benefited project operation, a minimum daily mean flow rate of 42.5 m^3/s at Saskatoon was established.

Since the power turbines cannot operate efficiently at this low flow rate, tests were done to determine whether brief releases at higher flows and then zero releases that averaged 42.5 m^3/s over a daily cycle would have adverse effects. It was found that the river channel stored the peak releases and that fairly steady flows developed at downstream points. Therefore, instantaneous flows are not limited so long as mean daily values meet the 42.5 m^3/s flow requirement at Saskatoon.

E. AGENCIES INVOLVED IN OPERATION

Operation of Lake Diefenbaker and Tobin Lake is accomplished through co-operative efforts of several agencies.

Lake Diefenbaker is operated in accordance with Part II of the 1958 Memorandum of Agreement between the Governments of Canada and Saskatchewan which provided for the constituting of a four-member Board of Officers known as the "South Saskatchewan Reservoir Board." This Board has two members from PFRA and two provincial members, one from Saskatchewan Environment and one from the Saskatchewan Power Corporation. This Board sets the overall operating policy for operation of Lake Diefenbaker.

Saskatchewan Environment develops weekly and seasonal flow forecasts and, in consultation with the Saskatchewan Power Corporation, co-ordinates and directs the day-to-day operation planning of Lake Diefenbaker within the policy guidelines set by the Reservoir Board.

The Squaw Rapids Generating Station and Tobin Lake are owned and operated by the Saskatchewan Power Corporation. Saskatchewan Environment provides inflow forecasts and co-operates with SPC in the development of operation plans for this project.

Water Survey of Canada and the Atmospheric Environment Service of Environment Canada in Saskatchewan and Alberta provide much of the basic data for flow forecasting and monitoring operation.